

## Description

# DIGITAL BROADCASTING TRANSMISSION/RECEPTION CAPABLE OF IMPROVING RECEIVING AND EQUALIZING PERFORMANCE AND SIGNAL PROCESSING METHOD THEREOF

### Technical Field

- [1] The present invention relates to a digital broadcasting transmission/reception system, and more specifically, to a digital broadcasting transmission/reception system generating stuff byte in a Moving Picture Experts Group-2 transport stream (MPEG-2 TS), and operating and transmitting a pattern of known data using the stuff byte to improve reception performance and equalization performance of a reception system and a signal processing method thereof.

### Background Art

- [2] The Advanced Television Systems Committee Vestigial Sideband (ATSC VSB) method, a U.S.-oriented terrestrial waves digital broadcasting system, is a single carrier method and uses a field sync by 312 segment unit. Accordingly, reception performance is not good in poor channels, especially in a Doppler fading channel.
- [3] Fig. 1 is a block diagram of a transmitter/receiver of a general U.S.-oriented terrestrial waves digital broadcasting system according to the ATSC digital television (DTV) standards. The digital broadcasting transmitter of Fig. 1 has a randomizer (110) for randomizing an MPEG-2 TS, an Reed-Solomon (RS) encoder (120) of a concatenated coder form for correcting errors generated by channels, an interleaver (130), and a 2/3 rate trellis encoder (140). The encoded data are mapped in 8 level symbol and are inserted with field syncs and segment syncs as shown in Fig. 2. After that, the data are inserted with pilots, VSB-modulated, upconverted into RF and transmitted.
- [4] Meanwhile, the digital broadcasting receiver of Fig. 1 lowers the RF signal to baseband, demodulates and equalizes the lowered signal, performs channel decoding, and restores the original signal in a reverse order of the digital broadcasting transmitter. Fig. 2 shows a vestigial sideband (VSB) data frame of the U.S.-oriented DTV system. In Fig. 2, one frame consists of two fields and one field has 312 data segments and field sync segment. One segment has segment syncs of four symbols and data symbols of 828 symbols.
- [5] As shown in Fig. 1, the digital broadcasting transmitter randomizes the MPEG-2 TS through the randomizer (110). The randomized data are outer-coded through the RS encoder (120) which is an outer coder, and the outer-coded data are dispersed through

the interleaver (130). The interleaved data are inner-coded by 12 symbol unit through the trellis encoder (140), and the inner-coded data are mapped in a 8 level symbol and inserted with the field syncs and segment syncs as shown in Fig. 2. Afterwards, the data have DC offset to generate the pilot, and are VSB-modulated, upconverted to a RF signal and transmitted.

- [6] Meanwhile, the digital broadcasting receiver of Fig. 1 converts an RF signal received through a channel into a baseband signal through a tuner/IF (not shown). The baseband signal is synchronization-detected and demodulated through a demodulator (210), and distortion by channel multipath is compensated through an equalizer (220). The equalized signal is error-corrected and decoded into symbol data through a trellis decoder (230). The decoded data, which have been dispersed by the interleaver (130) of the transmitter, are rearranged through a deinterleaver (240), and the deinterleaved data are error-corrected through an RS decoder (250). The error-corrected data are de-randomized through a derandomizer (260) and output into an MPEG-2 TS.
- [7] In the VSB data frame of the U.S-oriented terrestrial waves DTV system of Fig. 2, one segment corresponds to one MPEG-2 packet. In Fig. 2, the segment sync and field sync which are sync signals used for synchronization and equalization. The field sync and segment sync are known sequences and used as training data in the equalizer.
- [8] The VSB method of the U.S-oriented terrestrial waves digital television system of Fig. 1 is a single carrier system and has the low capacity to remove multipath in a multipath fading channel with Doppler. However, if the known sequence such as a field sync is used a lot, it becomes easier to estimate the channel and compensate the signal distorted by multipath in the equalizer using the known sequence.
- [9] However, as shown in the VSB data frame of the U.S-oriented terrestrial waves digital television system of Fig. 2, a field sync which is a known sequence appears in every 313 segment. This is not frequent so that the capacity to remove the multipath and equalize the received signal using this is low.

## **Disclosure of Invention**

### **Technical Problem**

- [10] An aspect of the present invention is to provide a digital broadcasting transmission system to improve reception performance and equalization performance of a reception system by adding a predefined known sequence, manipulating a pattern and transmitting a signal in a transmission system and a signal processing method, and a digital broadcasting reception system corresponding to the above and a signal processing method thereof.

### **Technical Solution**

- [11] A digital broadcasting transmitter according to the present invention includes a

randomizer for receiving and randomizing a data stream inserted with stuff bytes at a certain location, a sequence provider for generating known data having a particular sequence to replace the stuff bytes, a stuff byte replacer for inserting the known data at the location of the randomized data stream where the stuff bytes are inserted, an encoder for encoding the data stream output from the stuff byte replacer for error-correction, and a transmission part for modulating, RF-converting and transmitting the encoded data stream.

- [12] Preferably, the data stream includes the information on the certain location where the stuff bytes are inserted.
- [13] More preferably, the information is inserted prior to the location where the stuff bytes are inserted and includes the information on the length of the stuff data.
- [14] Additionally, the transmitter further may include a control signal generator for generating a control signal to control the stuff byte replacer to insert the known data at the location according to the information.
- [15] Preferably, the encoder includes an RS encoder for adding a parity of certain bytes to correct errors generated by channels, an interleaver for interleaving the data added with the parity in a certain pattern, and a trellis encoder for trellis-encoding the interleaved data.
- [16] In addition, the trellis encoder has a memory element for trellis encoding operation and initializes the memory element from the location inserted with the known data for trellis-encoding.
- [17] More preferably, the transmitter further including a packet buffer for receiving and temporarily storing the data stream from the RS encoder.
- [18] Further, the packet buffer receives the data altered according to the initialization of the memory element from the trellis encoder and updates the stored data.
- [19] Additionally, the transmitter further including a RS re-encoder & replace parity for RS-encoding the updated data input from the packet buffer, generating the altered parity, outputting the parity to the trellis encoder and replacing the parity added by the RS encoder.
- [20] Preferably, the interleaver outputs known data inserted at the same location of a plurality of different data streams output from the RS encoder in continuous data streams.
- [21] In addition, the transmission part modulates the data in VSB modulation.
- [22] Meanwhile, a signal processing method for digital broadcasting transmission according to the present invention includes receiving and randomizing a data stream inserted with stuff bytes at a certain location, generating a predefined particular sequence as known data, inserting the known data at the location inserted with the stuff bytes of the randomized data stream, encoding the data stream inserted with the known

data for error-correction, and modulating, RF-converting and transmitting the encoded data stream.

- [23] Additionally, a digital broadcasting receiver corresponding to the digital broadcasting transmitter according to the present invention includes a demodulator for inserting known data of a predefined particular sequence at a location in a data stream inserted with stuff bytes at the certain location, receiving the encoded signal from a digital broadcasting transmitter and demodulating the signal into a baseband signal, a known data detector for detecting the known data from the demodulated signal, and an equalizer for equalizing the demodulated signal using the detected known data.
- [24] Preferably, the known data detector includes a symbol number detector for detecting the information on the certain location inserted with the known data from a received signal, a segment flag generator for generating a data frame including at least one segment whose location is marked with a predetermined flag, a trellis interleaver for performing error-correction encoding performed in the digital broadcasting transmitter for the data frame, and a known data extractor for inserting the known data at the location marked with the flag of the encoded data frame and outputting the data.
- [25] More preferably, the known data detector outputs the detected known data to the demodulator and the demodulator performs demodulation using the known data.
- [26] Meanwhile, A signal processing method for digital broadcasting reception according to the present invention includes inserting known data having a predefined particular sequence at the location for a data stream inserted with stuff bytes at a certain location, receiving an encoded signal from a digital broadcasting transmitter and demodulating the signal into a baseband signal, detecting the known data from the demodulated signal, and equalizing the demodulated signal using the detected known data.

### **Advantageous Effects**

- [27] According to the present invention, a digital broadcasting transmitter generates and inserts stuff bytes in an MPEG-2 TS packet and transmits the inserted stuff bytes as known data, and a digital broadcasting receiver detects and uses the known data so that the digital broadcasting reception performance can be improved in poor multipath channels.
- [28] In addition, a sequence of the known data is manipulated in a pattern to improve performance of the equalization so that equalization performance and reception performance can be improved.

### **Brief Description of the Drawings**

- [29] Fig. 1 is a block diagram to show a transmitter of a general U.S-oriented terrestrial digital broadcasting system,

- [30] Fig. 2 is a view to show a frame structure of ATSC VSB data,
- [31] Fig. 3 is a view to show a frame structure of a TS packet,
- [32] Fig. 4 is a view to show a frame structure of a TS packet including a stuff byte,
- [33] Fig. 5 is a block diagram to show a digital broadcasting transmission/reception system according to an embodiment of the present invention,
- [34] Fig. 6 is a view to show a format of the data input to the randomizer of Fig. 5,
- [35] Fig. 7 is a view to show a format of the data output from the randomizer of Fig. 5,
- [36] Fig. 8 is a view to show a format of the data output from the RS encoder of Fig. 5,
- [37] Fig. 9 is a view to show a format of the data output from the data interleaver of Fig. 5,
- [38] Fig. 10 is a view to show a format of the data output from the trellis encoder of Fig. 5,
- [39] Fig. 11 is a view to show a format of the data output from an RS re-encoder according to trellis initialization of the known sequence section,
- [40] Fig. 12 is a view to describe the known symbol location detector/known data output of Fig. 5, and
- [41] Fig. 13 is a block diagram to show a digital broadcasting transmission/reception system according to another embodiment of the present invention.

### **Best Mode for Carrying Out the Invention**

- [42] Hereinafter, the present invention is described in detail with reference to the accompanying drawings.
- [43] Fig. 3 shows a frame structure of a TS packet and Fig. 4 shows a frame structure of a TS packet with a stuff byte. The TS packet of Fig. 3 consists of a MPEG-2 header, adaptation field or ES data. According to the present invention, stuff bytes are inserted in a packet of Fig. 4 as shown in Fig. 3 so that all the TS streams have adaptation fields.
- [44] That is, the MPEG-2 TS packet of Fig. 4 is an MPEG-2 packet of 188 bytes and consists of an MPEG-2 header of 4 bytes with MPEG syncs, an adaptation field length section of 1 byte indicating length of the adaptation field, an adaptation field data section having other information of 1 byte and stuff bytes of N bytes, and ES data of  $188-(4+2+n)$  bytes.
- [45] Fig. 5 is a block diagram to show a digital broadcasting transmission/reception system according to an embodiment of the present invention. In Fig. 5, the digital broadcasting transmitter receives an MPEG-2 packet TS having the packet structure of Fig. 4 through a TS multiplexer (not shown).
- [46] In Fig. 5, the digital broadcasting transmitter has a randomizer (310) for randomizing the input TS stream, a stuff byte replacer (315) for replacing the stuff byte

of the randomized data with a particular sequence, an RS encoder for constructing the data output from the stuff byte replacer (315) in the concatenated code form to correct errors generated by channels, an interleaver (330) for interleaving the data, a packet buffer (325) for storing the RS-encoded reference data to initialize a memory of a trellis encoder (340) and replacing the previous value with an initialized value, an RS re-encoder & replace parity (335) for performing RS-encoding using the altered value, generating a parity and inputting the parity to the trellis encoder (340), the trellis encoder (340) for converting the interleaved data into symbols and performing 2/3 rate trellis encoding and 8 level symbol mapping, a multiplexer (350) for inserting field syncs and segment syncs as shown in Fig. 2, a transmission part (360) for inserting a pilot, performing VSB-modulation, upconverting the data into RF and transmitting the data, and a control signal generator (370) for generating a signal to control data processing.

- [47] In Fig. 5, the digital broadcasting receiver goes through a reverse order of the transmitter and has a demodulator (410) for lowering the RF signal to baseband and demodulating it, an equalizer (420) for removing inter-symbol interference, a Viterbi decoder (430) for performing error-correction and decoding, a deinterleaver (440), an RS decoder (450), and a derandomizer (460). Additionally, the receiver further includes a known symbol location detector/known symbol output (470) for detecting and outputting the location of the known symbol from the demodulated data.
- [48] Further, Fig. 12 is a block diagram to show the known symbol location detector/known symbol output (470) in detail, and the known symbol location detector/known symbol output (470) includes a known symbol number detector (471), a segment flag generator (473), a trellis interleaver (475) and a known data extractor (477).
- [49] In the digital broadcasting transmitter, if the information on the number of stuff bytes is inserted in the reserved part of the field sync data segment section, the known symbol number detector (471) of the known symbol location detector/known symbol output (470) of the receiver detects the information on the number of the known data, the segment flag generator (473) and trellis interleaver (475) find the information on the location of the known symbol based on the detected information, the known data extractor (477) outputs the known data according to the acquired information on the location, and the known data are used to improve reception performance of the receiver. If the information on the number of the stuff bytes is acquired, as the location of stuff bytes is always fixed, the segment flag generator (473) and trellis interleaver (475) can be implemented using a counter and control logic.
- [50] Meanwhile, an MPEG-2 packet TS having the packet structure of Fig. 4 is input to the randomizer (310) through the TS multiplexer (not shown), randomized, replaced with a particular sequence for the stuff bytes by the stuff byte replacer (315) and

output. The output data are outer-coded through the RS encoder (320) to correct errors by channels and the outer-coded data are dispersed through the interleaver (330).

[51] Subsequently, the interleaved data are inner-coded by a 12 symbol unit through the trellis encoder (340). The inner-coded data are mapped in 8 level symbol and inserted with the field syncs and segment syncs as shown in Fig. 10 by the multiplexer (350). And then, the data have DC offset to generate a pilot and are VSB-modulated, up-converted into RF and transmitted.

[52] Meanwhile, the control signal generator (370) detects the adaptation field length of Fig. 4, and generates and outputs a flag signal to indicate the location of stuff bytes or known sequence data based on the detected result.

[53] Further, in Fig. 5, the trellis encoder (340) performs initialization of 12 trellis encoder at the beginning location of the known sequence, for example, in order for the value of the memory element of the encoder to become '00'. The sequence altered by the initialization replaces the value stored in the packet buffer (325) and the new parity generated by the RS re-encoder & replace parity (250) replaces the value of the original parity location input to the trellis encoder (340) so that the initialization is performed.

[54] Fig. 6 to Fig. 10 show data formats while an MPEG-2 packet with stuff bytes passes through channel encoder blocks of the digital broadcasting transmitter.

[55] Fig. 6 shows a format of the data input to the randomizer (310) and Fig. 7 shows a data format after replacing n stuff bytes of the randomized data with particular sequence data. Fig. 8 shows a data format of the RS-encoded data added with RS parity and Fig. 9 shows a data format of the data output from the interleaver (330).

[56] Further, Fig. 10 shows a format of the 12 symbol interleaved data output from the trellis encoder (340). Fig. 11 is a format of the data whose parity is restructured by the RS re-encoder & replace parity (335) of Fig. 3. In Fig. 10, one field includes six convolutional interleavers, so there are six sequences with stuff bytes. That is, if a TS includes stuff bytes of 10 bytes, one field has known sequences of  $10 \times 6 = 60$ . If the trellis encoder (340) is initialized at the beginning location of the known sequence, the output parity of the RS encoder (320) is altered by the value of initialization and trellis encoding is performed by updating with the altered parity.

[57] The MPEG-2 packet of Fig. 6 is dispersed by 52 units by the interleaver (330) as shown in Fig. 9. The data located in the same byte of the MPEG-2 packet constructs the same column as shown in Fig. 9 after data interleaving. Additionally, the interleaved data are 12-symbol-interleaved by the trellis encoder (230) as shown in Fig. 10. That is, the data of the same location in MPEG-2 packets construct almost one data segment as shown in Fig. 10 after trellis encoding. Therefore, if a particular part of an MPEG-2 packet is continuously added with stuff bytes, randomized, replaced with a

particular sequence and trellis-encoded, the stuff bytes form one data segment which is a known signal and a digital broadcasting receiver uses the known signal to improve reception performance.

- [58] Fig. 11 shows a data format after RS re-encoding and parity restructuring by the RS re-encoder & replace parity (335) of Fig. 5. That is, if the trellis encoder (340) is initialized at the beginning location of sequence of the known symbol, output parity of the RS encoder (320) is altered by the value of the initialization and trellis encoding are performed by being updated with the altered parity so that there is no problem in decoding of the RS decoder of a digital broadcasting receiver which will be described below. That is, the trellis encoder is initialized in order for the trellis-encoded data to form a regular sequence during the known symbol sequence section, RS encoding is performed to replace the data of the initialization location so that parity is altered and the altered parity replaces the original parity. Fig. 11 shows the data format.
- [59] Meanwhile, the demodulator (410) of a digital broadcasting receiver downconverts the RF signal received through a channel into a baseband signal through a tuner/IF (not shown), and the converted baseband signal is sync-detected and demodulated. The equalizer (420) compensates channel distortion by multipath of channels in the demodulated signal.
- [60] Meanwhile, a known symbol location detector/known data output (470) detects information on the number of stuff bytes inserted in the reserved section of field sync data segment section, acquires information on the location of the known symbol and outputs the known data from the acquired information on the location.
- [61] In a digital broadcasting transmitter, if the information on the number of stuff bytes is inserted in reserved section of field sync data segment section, a known symbol number detector (471) of a known symbol location detector/known data output (470) of the digital broadcasting receiver detects the information on the number of the known data, a segment flag generator (473) and trellis interleaver (475) find the location information of the known symbol based on the information, and a known data extractor (479) outputs and uses the known data from the acquired information to improve reception performance of the digital broadcasting receiver. As the location of stuff bytes is always fixed, if the information on the number of the stuff bytes is acquired, the segment flag generator (473) and trellis interleaver (475) can be implemented using a counter and control logic.
- [62] Meanwhile, the equalized signal by the equalizer (420) is error-corrected through the Viterbi decoder (430) and decoded in symbol data. The decoded data rearrange the data dispersed by the interleaver (330) of the digital broadcasting transmitter through the deinterleaver (440). The deinterleaved data are error-corrected through the RS decoder (450). The error-corrected data are derandomized through the derandomizer

(460).

- [63] Fig. 13 is a block diagram to show a digital broadcasting transmission/reception system according to another embodiment of the present invention. In Fig. 13, the digital broadcasting transmitter has a randomizer (310) for randomizing data of the input TS stream, a stuff byte replacer (315) for replacing the stuff byte of the randomized data with a particular sequence generated in a replacement sequence generator (513), an RS encoder for constructing the data output from the stuff byte replacer (315) in the concatenated code to correct errors generated by channels, an interleaver (330) for interleaving the data, a packet buffer (325) for storing the RS-encoded reference data to initialize a memory of the trellis encoder (340) and replacing the stuff byte with an initialized value, an RS re-encoder & replace parity (335) for performing RS-encoding using the altered value to generate parity and inputting the data to the trellis encoder (340), the trellis encoder (340) for converting the interleaved data into a symbol and performing 2/3 trellis encoding and 8 level symbol mapping, a multiplexer (350) for inserting a field sync and segment sync as in the data format of Fig. 2, a transmission part (360) for inserting a pilot, performing VSB-modulation, converting the data into RF and transmitting the data, and a control signal generator (370) for generating a signal to control data processing.
- [64] In Fig. 13, the digital broadcasting receiver follows a reverse order of the transmitter and includes a demodulator (410) for lowering the RF signal to baseband and demodulating it, an equalizer (420) for deleting inter-symbol interference, a Viterbi decoder (430) for error-correcting and decoding, a deinterleaver (440), an RS decoder (450), and a derandomizer (460). Additionally, the receiver further includes a known symbol location detector/output (470) for detecting and outputting the location of the known symbol from the demodulated data.
- [65] The function and operation of each component of the digital broadcasting transmission/reception system of Fig. 13 are similar to those of Fig. 5. Therefore, a detailed description of the same function and operation is omitted and the difference will be described.
- [66] A stuff byte replacer (515) replaces stuff bytes of the data randomized by the randomizer (310) with a particular sequence and outputs the data. In this case, a pattern of the particular sequence may be preferably adjusted in order for the symbols mapped through the trellis encoder (540) to be well operated by the equalizer (620).
- [67] Therefore, according to another embodiment of the present invention, the digital broadcasting transmitter further includes the replacement sequence generator (513) for generating a particular sequence to replace the stuff bytes and providing the particular sequence to the stuff byte replacer (515) in order for the pattern of the known sequence generated by replacing the stuff bytes to well operate the equalizer (620).

- [68] According to another embodiment of the present invention, as shown in Fig. 11, the block diagram of Fig. 5 further includes the replacement sequence generator (513), and a parity reconstruction (535) of the transmitter and a known data detector (670) of the receiver operate differently from the digital broadcasting transmission/reception system of Fig. 5.
- [69] The replacement sequence generator (513) includes a memory (not shown) for storing the particular sequence to replace the stuff bytes in the stuff byte replacer (515) and a circuit (not shown) for controlling a memory address.
- [70] If the sequence pattern of the known data of Fig. 9 and Fig. 10 has a random pattern without DC offset, operation performance of the equalizer can be improved. Accordingly, the replacement sequence generator (513) may preferably generate a particular sequence to replace the stuff bytes so that the sequence pattern of the known data mapped after trellis encoding of the trellis encoder (540) in the stuff byte replacer (515) has the random pattern without DC offset.
- [71] First, in order for the sequence of the known data to have a desirable pattern, the memory value of the trellis encoder (540) has to be initialized.
- [72] The compatibility is maintained with the existing receiver and the memory value of the trellis encoder (340) is initialized by the packet buffer (325) and RS re-encoder & replace parity (335) of Fig. 5. According to a method of an embodiment of the present invention, the method initializes the memory value of the trellis encoder (340) of part of the stuff bytes according to the number of stuff bytes instead of the entire stuff bytes in order to be compatible with the existing receiver. Accordingly, the initialized stuff bytes can limitedly have a desirable pattern.
- [73] Therefore, in another embodiment of the present invention, the function of initializing a memory value of the trellis encoder (540) for the entire stuff bytes, with the compatibility with the existing receiver ignored, is added to the RS re-encoder & replace parity (540). That is, the RS re-encoder & replace parity (540) is compatible with the existing receiver and initializes the memory value of the trellis encoder (340) according to an embodiment of the present invention depending on initial set-up and user choice, and ignores the compatibility with the existing receiver and initializes the memory value of the trellis encoder (540) for the entire stuff bytes according to another embodiment of the present invention.
- [74] In addition, the known symbol location detector/known data output (670) of the receiver is added with the function corresponding to the added function of the parity reconstruction (535) of the transmitter.
- [75] The value of the part that initializes the memory value of the trellis encoder of the particular sequence, which is generated in the replacement sequence generator (513) and replaces the stuff bytes in the stuff byte replacer (515), can be any value. The re-

placement sequence generator (513) considers the symbol value which is mapped after trellis-encoding according to the memory value to have the desired pattern by the sequence of the known data wants after the initialization, and generates the particular sequence to replace the stuff bytes.

- [76] The replacement sequence generator (513) stores the above particular sequence in the memory (now shown) and is controlled to adjust the sync by a control signal generator (570). Accordingly, the sequence of the known data is operated to improve the operation performance of the equalizer so that performance of the equalizer is improved and performance of the receiver is improved.
- [77] As above-described, stuff bytes are generated and inserted in an MPEG-2 TS packet, the inserted stuff bytes are transmitted as known data from the digital broadcasting transmitter and the digital broadcasting receiver detects and uses the known data so that reception performance such as sync acquisition and equalization performance can be improved.
- [78] In addition, the sequence of the known data is operated to improve operation performance of the equalizer so that the performance of the equalizer can be improved and reception performance of the receiver can be improved.